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Television Reception at "Shadowed" Locations

By the Engineering Department, Aerovox Corporation

ONE of the most prevalent problems confronting the rural TV viewer and his service technician is that of providing reception at receiving sites well within the normal service range of one or more transmitters but "shadowed" by topographical details. In hilly or mountainous terrain, many communities and, indeed, whole cities, are in the vexing position of having strong, steady television signals *going by* a few hundred feet overhead, but with little or no signal available to antennas of practical height in the valley. A typical situation of this kind is depicted in Fig. 1.

The social and economic implications of this common situation are many and seem a high price to pay for a wrinkle on the surface of the earth formed long before anyone had television transmission in mind. To the viewer, it means missing out on the educational and entertainment miracle of television. To the TV dealer and serviceman it means whole fields of potential set sales and servicing lying fallow. And, of course, to the television broadcaster and advertiser, it means reduced coverage. This issue of the AEROVOX RESEARCH WORKER is devoted to a discussion of some of the solutions which have or might be resorted to in such instances.

There are several approaches which might be used in "illuminating" a television receiver or community situated as in Fig. 1. They include:

(a) A *booster station* located on the hill top at "A" and relaying the signal on the same frequency.

(b) A *sattelite station* situated at "A" rebroadcasting the signal on another frequency, such as a UHF channel.

(c) A *"passive relay" antenna* at "A" receiving the television signal and re-radiating it into the valley.

(d) A *community antenna* located on the hill top with a transmission line distribution system feeding receivers in the valley.

In evaluating the applicability of these approaches to specific locations, there are many legal, economical, and technical factors to be considered. We will now examine some of these.

The Booster Station

The operation of a relay transmitter modulated by the distant TV station involves considerable legal and technical complication. Legally it would require a license by the Federal Communications Commission as well as an agreement with the television station whose programs were to be relayed. It also requires a source of electrical power at the relay station site as well as frequent or continuous attendance. In general, the expense involved makes this the type of endeavor which must be financed on a commercial basis, rather than run as a community enterprise. Nevertheless, experimental booster stations of this kind have been authorized by the F. C. C.[1]

The block diagram of a typical equipment lay-out required by a booster station is given in Fig. 2. A high gain receiving antenna oriented to receive the signal of the desired TV station, to the exclusion of any other on the same channel, feeds a low-noise r.f. amplifier. This drives a linear power amplifier which builds the signal up to the level required for re-radiation by a second antenna oriented to illuminate the desired

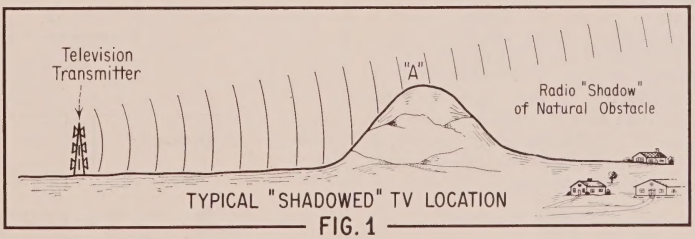

FIG. 1

AEROVOX - The Sign Of The Complete Capacitor Line

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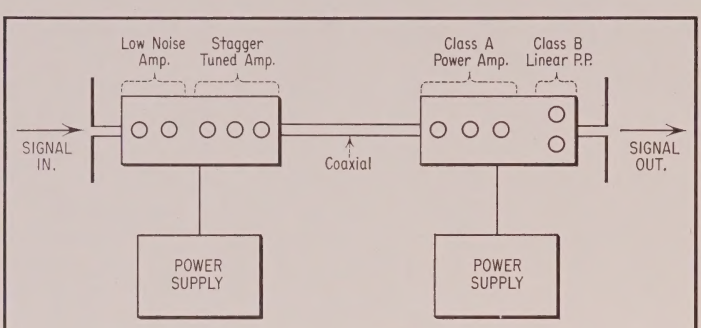


ELEMENTS OF BOOSTER RELAY STATION

FIG. 2

coverage area. For single channel relaying, the bandwidth of the overall system must be at least six megacycles. The total system gain will depend, of course, upon the signal strength available from the master station. In "fringe" areas, at least 100 decibels of overall gain must be provided if the coverage angle is large. Usually the power fed to the transmitting antenna need only be a few watts.

One of the technical difficulties encountered in the operation of a booster re-radiating on the same channel as the master station is that of feed-back. Enough isolation must be provided between the output and input to prevent such regeneration. This is usually accomplished by utilizing antennas with high front-to-back ratios placed back-to-back. Additional isolation is also available by placing the receiving antenna and associated low-level preamplifier equipment a few hundred feet from the power amplifier and transmitting antenna. A high grade coaxial cable is used to interconnect the two.

One economic factor in favor of the booster approach is the fact that no expensive frequency control and sweep generator standards are required. Since the booster station is essentially a linear amplifier, all of the standards are established by the master station. Thus, the cost of an installation of this type is much less than that of a small station capable of originating programs, but is still prohibitive for the isolated viewer or small community.

Satellite Stations

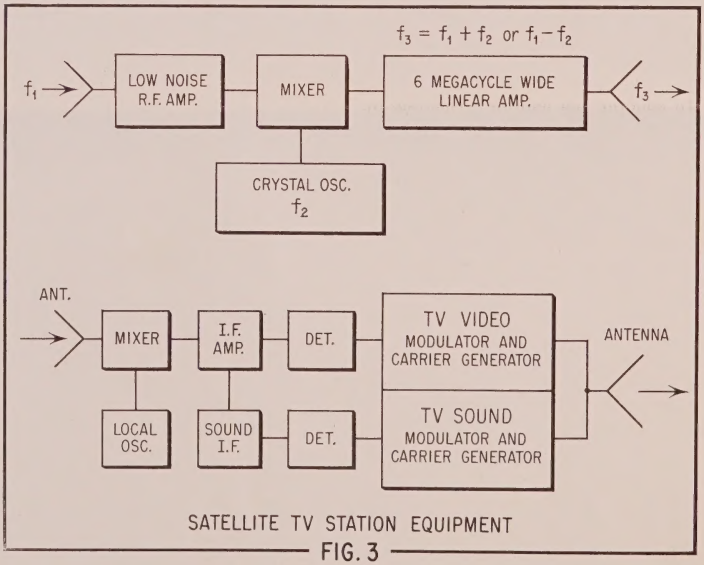
Relaying the television signal on another channel frequency, such as a UHF channel, is even more complicated than same-channel relaying in many respects. In addition to requiring FCC authorization and master station permission, considerably more equipment is needed. Since the only manner in which the channel frequency can be changed is by heterodyning the master station carrier to a new frequency or by modulating a locally generated carrier on the new frequency with the video signal of the master station, facilities for maintaining the required frequency stability will be required in either case. On the other hand, the problem of input-output isolation is eliminated in a relaying system of this kind, since the frequency transmitted is different from that received from the master station. The satellite station can be arranged to select any one of several master station signals available and relay them on the allocated frequency.

Block diagrams of two possible equipments for satellite station relaying are shown in Fig. 3.

Passive TV Relaying

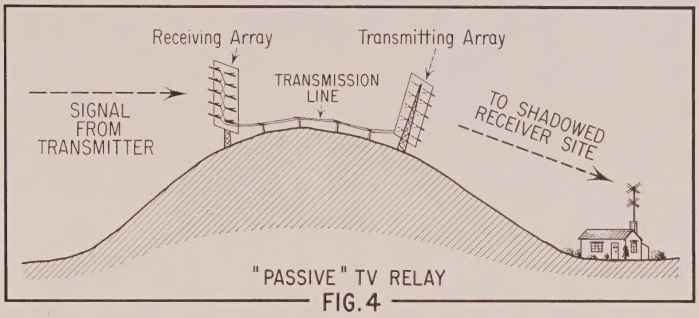
Another interesting possibility for television relaying in locations where a strong signal from the master station is available might be called "passive" relaying. The essentials of this scheme are illustrated in Fig. 4. A high gain antenna situated on a high place within line-of-sight of both the transmitter and the shadowed receiver sites receives the signal from the TV station and feeds it to another high-gain antenna oriented to re-radiate the signal into the valley. This system has proven practical in several instances.[2] It has many advantages over the foregoing systems which put it within the reach of the single isolated receiving site or the small community.

Since this system is totally "passive", i. e., does not employ amplifying or transmitting equipment of any kind, F. C. C. approval has not been required. For the same reason, no source of electrical power is required at the relaying site and a minimum of maintenance is necessary. These are decided advantages since the sites which are suitable for relaying of this kind are usually quite inaccessible. Another advantage offered by the passive antenna system is that of multi-channel operation. If several strong stations are located in the same direction, it will usually be possible to relay all of them simultan-



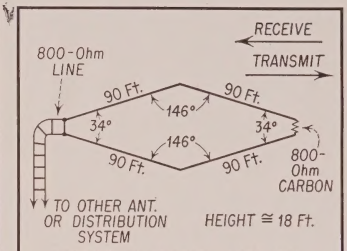
SATELLITE TV STATION EQUIPMENT

FIG. 3



"PASSIVE" TV RELAY

FIG. 4



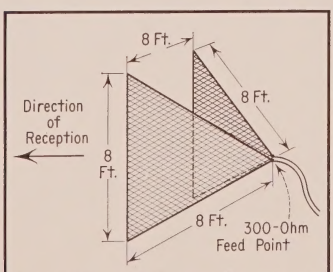
LARGE RHOMBIC ANTENNA FOR TV RELAYING
(Top View)

FIG. 5

eously. In general, multi-channel installations will require the use of more elaborate antenna arrays, however.

If the site available for relaying is sufficiently large the rhombic antenna offers high gain and broadbanded operation while involving little expense. It can be constructed of wire, as contrasted to the more expensive aluminum tubing required in some other high gain designs. If the site is wooded, trees can usually be pressed into service to support the corners of the rhombics. Because the radiation pattern of a large rhombic is rather sharp, care must be taken to properly align both the receiving and the transmitting antennas. The major lobe of the rhombic is usually tilted a few degrees above the plane of the antenna. For this reason, it might be convenient to place the two antennas on opposite sides of the obstructing hill and interconnect them with a low-loss, high-impedance transmission line. Fig. 5 shows the dimensions of a rhombic antenna design which would be suitable at some locations. Other design information can be found in references 3 and 4. In general, the gain of a rhombic increases with the number of wavelengths per leg.

Another antenna type which could be used is the "chicken-wire horn" illustrated in Fig. 6. This design provides all-channel operation and reasonably high gain while requiring less space than the rhombic. Two such antennas could be used back-to-back at the crest of the hill or separated by some distance and connected with 300 ohm line. Of course, the length of the line should be kept to a minimum since its losses detract from the gain provided by the antennas.



"CHICKEN-WIRE HORN" ANTENNA

FIG. 6

Other high gain TV antenna designs could be utilized for passive relaying. In instances where only single channel operation is desired, multi-element stacked Yagi designs, cut for the proper frequency will provide good gain and directivity in small space. Antennas of the "billboard" type should also be useful.

In the choice of the transmitting antenna, attention must be given to the angle of radiation. If the receivers are spread out over considerable area close to the re-radiating antenna, the pattern of this antenna must be wide enough to illuminate all of them. Since the object of the relaying system is to provide as much total system gain as possible, the antennas at the receiving sites must also be high gain designs of the variety usually employed in fringe areas. They, in turn, must be accurately oriented on the hill-top relaying antenna.

Community Antenna Systems

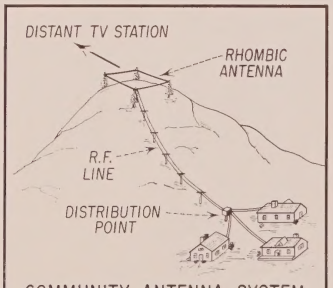
At locations where the receiving sites are only a few hundred yards from an elevated place where relatively strong television signals can be received, the community antenna scheme has been used successfully. As illustrated in Fig. 7, this system utilizes a high gain antenna on a high place and a long, low loss transmission line distribution system to "pipe" the signal to one or more receivers.

Technically, the problems associated with the community antenna approach are very similar to those involved in providing reception in large apartment buildings. The gain of the receiving antenna must be sufficient to off-set the losses of the feed line, and provisions must be made to isolate the various receivers to prevent interaction between them. Cathode-follower isolation stages or resistive isolation pads are usually employed for the latter purpose. Special attention must also be given to lightning protection in such installations, since an antenna on a high place is especially prone to such phenomena.

Low losses, consistent with economy, is the main factor to be considered in the choice of the transmission line between the hill-top antenna and the receiver distribution point. Several suitable types were discussed in the AEROVOX RESEARCH WORKER for December, 1952. Special consideration should be given to the high impedance, open wire line and the surface wave transmission line. The cost of installation of the latter decreases with frequency, making it attractive for UHF use.

REFERENCES

(1) Electrons at Work, Electronics, March, 1953.
(2) R. C. Webb, Electronics, March, 1953.
(3) Radio Amateur's Handbook, 1953
(4) J. Minter, Electronic Industries, Oct., 1946.



COMMUNITY ANTENNA SYSTEM

FIG. 7

It's the exclusive **AEROLENE** impregnant that makes the difference . . .

Aerolite tubulars—hermetically-sealed metal-case units, with or without insulating jackets. Featuring vitrifed terminal seal.

Space-saver metal-case Aerolites are available in rectangular-can and in bathtub housings, in widest range of terminals and mountings.

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Aerolite (metallized-paper) capacitors with Aerolene impregnant, offer longer service life, lower radio-frequency impedance, and extended electrode construction with soldered connections at all electrical contacts. The accompanying graphs tell their own story of superior performance.

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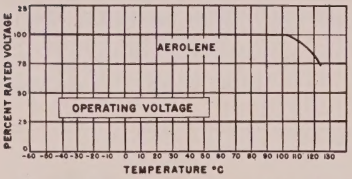
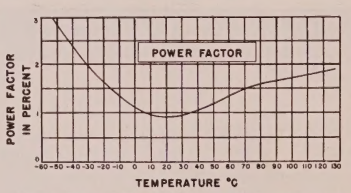
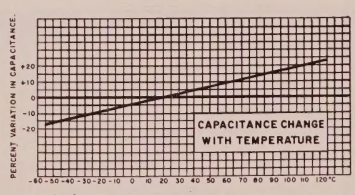


Temperature Range: Operating at working voltage equal to rated voltage over temperature range of minus 55° C to plus 100° C; and at working voltage equal to 75% of rated voltage up to 125° C.



Power Factor: 1.5% or lower at 25° C, when measured at or referred to a frequency of 1000 cycles per second on capacitors up to and including 1.0 mfd.; and when measured at or referred to frequency of 60 cycles, on capacitors greater than 1.0 mfd.



Nominal Capacitance up to and including 1.0 mfd. is measured at or referred to at frequency of 1000 cycles per second at 25° C. Capacitors above 1.0 mfd., measured at or referred to frequency of 60 cycles per second at 25° C.

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